4.0 Screening Assessment of Risk to the Environment

This section describes the process used to assess potential risk to the environment and the results of that assessment. Section 5.0 describes the process used to assess potential risk to human health and the results of that assessment.

The assessment of potential risk to the environment is divided into two parts. The first part describes the process for choosing the species to be included in the assessment. Over 350 species from the riparian zone along the Columbia River and species that live in the Columbia River were evaluated through a two-tiered process. The result of the process was the selection of 52 species including aquatic and terrestrial plants, aquatic invertebrates, amphibians, reptiles, fish, birds, and mammals. The second part of the assessment describes the risk assessment for the chosen species and the results of the ecological risk screening assessment. Measurement endpoints for the assessment are defined. The ecological risk assessment is based on conceptual models for exposure of contaminants to water-respiring and air-respiring species. Exposure conditions and parameters for assessing exposure are presented in Appendix I-D. Two modes of the ecological risk assessment model, deterministic and stochastic, are discussed. Finally, the results of the model are discussed in terms of risks for contaminants and risks for species across the segments of the Columbia River.

4.1 Species for the Screening Assessment

The objective of the ecological risk assessment is to determine whether Hanford-derived contaminants from the Columbia River pose a threat to species that exist in the river and riparian communities of the study area. Because these communities consist of numerous species, the first step was to select the species to be assessed. This section describes the process that identified which species should be assessed. The second step in the ecological risk assessment was to estimate the potential risk to the selected species. Section 4.2 describes that process and potential risk to the selected species.

To assess potential risk to the environment, we first needed to decide which species to evaluate. Because this is a screening assessment, only a limited number of species were evaluated:

- **those most likely to be exposed to contaminants**
- **those of high concern for cultural and natural resource management reasons**
- **those that ensure each major group of species is represented**

Both a panel of regional biologists and the CRCIA Team were involved in setting the criteria to decide which species to evaluate.

The Columbia River is a complex ecosystem that supports numerous species. Once contaminants have entered into the riparian or aquatic ecosystems, all species in the relevant food webs may be considered potential contaminant species. For the screening assessment of risk to the environment, the number of species to be evaluated was reduced to those that have a high potential for exposure to contaminants and that are culturally and ecologically important to the CRCIA Team. A two-tier screening approach was used to select the species for this risk assessment.

The CRCIA assessment of potential risk to the environment is a screening study because it is limited in its spatial and temporal scope and in the number of species it evaluates, and it addresses only the issue of whether contaminants exceed levels that harm identified species. It does not attempt to address the average hazard of contaminants because this would require significantly more information on the temporal and spatial fluxes of contaminants and distributions of species than the scope of the screening assessment will allow. Instead, this risk assessment evaluates direct effects (for example, mortality) to selected species caused by exposure to contaminants. Indirect effects (for example, repercussions in the food chain that may result from direct effects to selected species) at the population and community levels are beyond the scope of this screening assessment. The results of this risk assessment focus a subsequent and more comprehensive risk assessment that will likely evaluate 1) a larger segment of the Columbia River, 2) hazards posed by past, present, and future contaminant fluxes, and 3) a larger number of selected species.

4.1.1 Ecosystem

The portion of the river within the study area (vicinity of Priest Rapids Dam to McNary Dam) lies within the lower Columbia River Basin, which is a part of the western intermountain sagebrush steppe ecosystem (West 1988). The ecology of the aquatic and riparian systems within the study area has been studied extensively in the last 50 years, largely because of concerns about hydropower and reactor construction and operation. Major summaries of biological studies conducted in association with Hanford Site operations include Becker (1990) and Cushing (1995). Studies specific to biological resources of the river and riparian areas at the Hanford Site include Weiss and Mitchell (1992) and Landeen et al. (1993) for the 100 Areas and Brandt et al. (1993) for the 300 Area. Studies relating to the Washington Public Power Supply System reactors at the Hanford Site are summarized in Page et al. (1982). Studies in support of the proposed U.S. Army Corps of Engineers Ben Franklin Dam are summarized in Fickeisen et al. (1980). Other documents describing the climate and abiotic portions of the study area are cited in Cushing (1995).

Fortunately for purposes of this study, the ecology of the aquatic and riparian systems of the Hanford Reach has been studied extensively over the past 50 years. As a result, we were able to identify existing species based on these studies without conducting additional field research. Key terms to be familiar with when reading about the ecosystem are as follows:

- **An aquatic ecosystem contains species that grow and live in or upon water.**
- **A semi-aquatic ecosystem contains species that grow and live partially in or upon water and partially on land.**
- **A riparian ecosystem contains species that grow and live on the banks of a body of water, in this case the Columbia River.**
- **Riverine habitat is in the river, in this case the Columbia River.**
- **Food web describes the foraging relationships (what eats what) among groups of species. Basic groups in the food web are carnivores (meat eaters), omnivores (meat and plant eaters), herbivores (plant eaters), and producers (plants). Generally, producers are at the bottom of the food web. Carnivores are at the top. Producers are eaten by herbivores. Herbivores are eaten by omnivores. Omnivores are eaten by carnivores, which means the carnivores may also be affected by contaminants contained in the producers and herbivores as well as the omnivores. Any member of the food web may be affected by contaminants contained in its prey. The labels, carnivores I, II, and III, in Figure 4.2 indicate that carnivores II eat carnivores I and carnivores III eat carnivores II and I.**

All these documents cited above will not be reviewed in this screening assessment. The reader is referred to the above sources for detailed discussions of the Hanford Reach and its biological resources. Key points of the riparian and aquatic ecosystems under study are provided below. Common names are used in the following description. Table C.1 in Appendix I-C provides the Latin nomenclature.

The Hanford Reach comprises the last unimpounded portion of the Columbia River in the United States above Bonneville Dam. It supports diverse plant, fish, and wildlife species that are locally abundant. Food webs that pictorially display the foraging interrelationships of species of the riparian and aquatic ecosystems in the study area are presented in Figures 4.1 and 4.2, respectively.

4.1.1.1 Riparian Community

The dominant riparian vegetation includes black cottonwood, bulrushes, common cattail, reed canary grass, white mulberry, willows, and numerous species of sedges and forbs. The riparian zone of the study area is known to include four plants on Washington State protected species lists: Columbia yellowcress (state endangered), dense sedge (state sensitive), false pimpernel (state sensitive), and southern mudwort (state sensitive) (WNHP 1994; Sackschewsky et al. 1992).

Fitzner and Gray (1991) listed 39 species of mammals known to occur on the Hanford Site. Brandt et al. (1993) identified 24 as occurring within the riparian zone of the Columbia River. Principal herbivorous species include beaver, deer mice, mule deer, and muskrat. Insectivorous species include several species of Myotis bats that forage primarily on emergent insects, and the northern grasshopper mouse and vagrant shrew that forage primarily on terrestrial insects and other arthropods. Omnivores include coyote, raccoon, and striped skunk. Predators include bobcat, mink, river otter, and weasels. Two bats, the pallid bat and long-eared Myotis bat, and the northern grasshopper mouse are listed as a monitor species by Washington State (WDW 1994).

Weiss and Mitchell (1992) identified 103 bird species associated with the riparian community of the Hanford Reach. These include species that use the area only during winter (for example, American widgeon, bald eagle), only during summer (for example, cliff swallow, Forster's tern,), or year-round (for example, barn owl, mallard). Principal herbivorous species include Canada geese and mallards. Principal omnivorous species include black-billed magpie, California quail, American crow, the dabbling (primarily herbivorous) ducks (for example, Northern pintail and teal), common raven, and ring-necked pheasant. Carnivores and insectivores comprise the bulk of the avifauna, which includes species such as bald eagle, belted kingfisher, black-crowned night heron, great blue heron, gulls, hawks, owls, shorebirds, swallows, and terns. Two birds, Aleutian Canada goose and bald eagle, are listed as threatened under the Endangered Species Act. Aleutian Canada goose, American white pelican, bald eagle, ferruginous hawk, and sandhill crane are listed as either threatened or endangered by Washington State. The common loon is a candidate for listing as threatened or endangered by Washington State (WDW 1994).

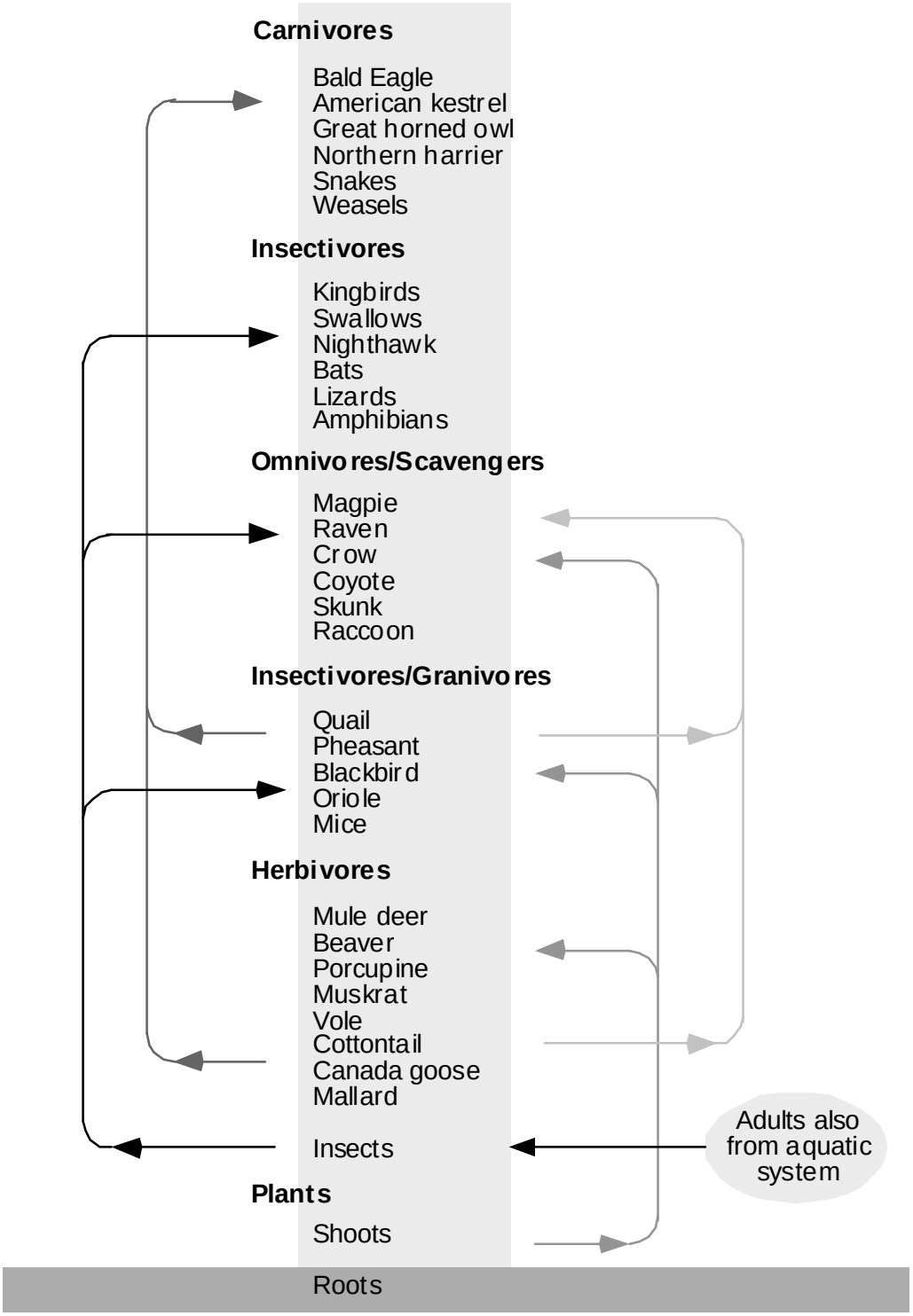

Figure 4.1. Riparian Food Web for the Ecological Risk Screening Assessment of the Columbia River (Detrital/decomposing components are not represented.)

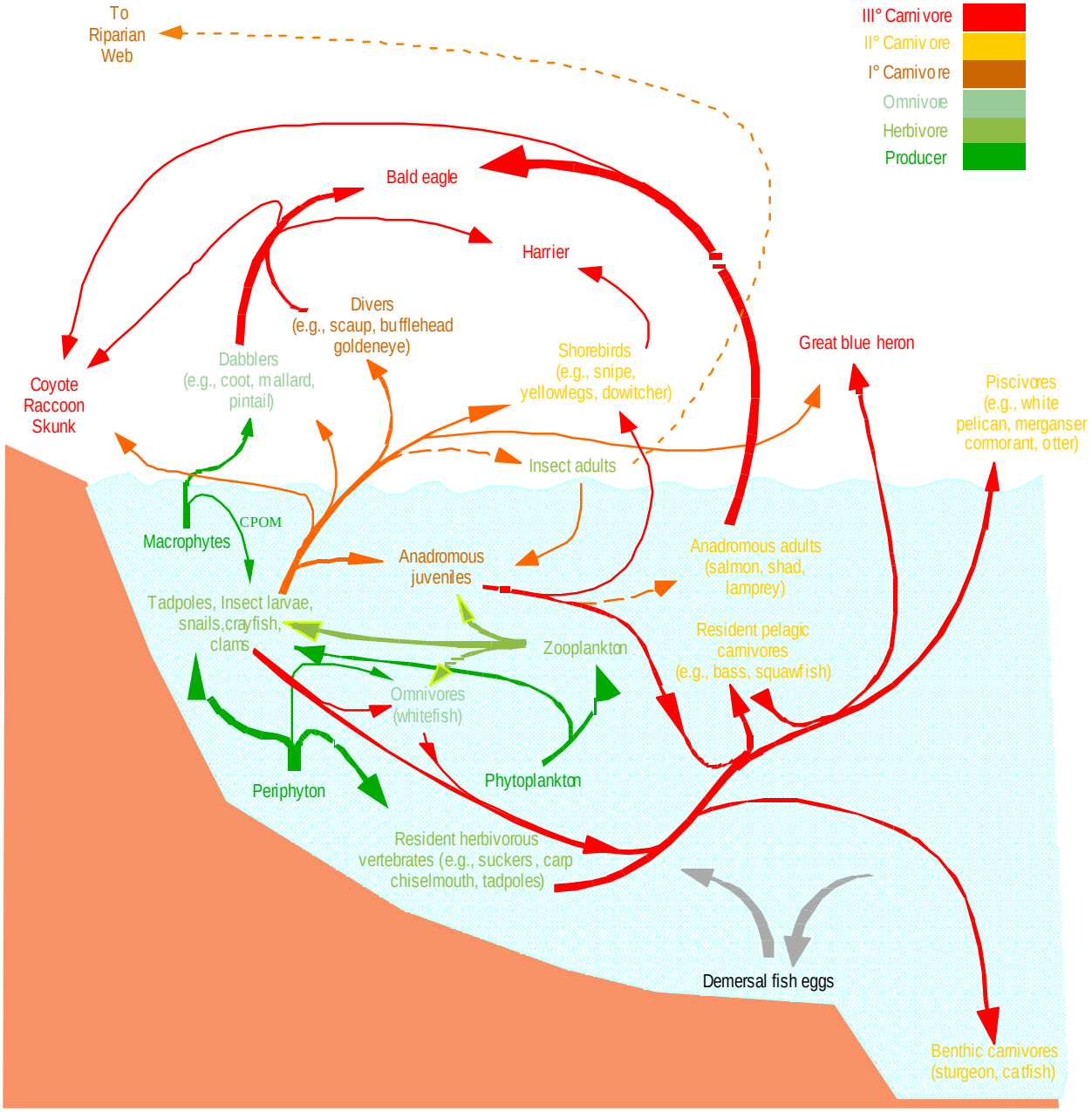

Figure 4.2. Aquatic Food Web for the Ecological Risk Screening Assessment of the Columbia River (Detrital/decomposing components are not represented. Line widths represent the approximate level of biomass flow. Dashed lines indicate developmental transformation to a different life style. Legend colors apply only to organisms' names, not to the arrows.)

Amphibians in the study area include the bullfrog, Great Basin spadefoot toad, Pacific tree frog, and Woodhouse's toad (Brandt et al. 1993). While none are abundant within the region, all use backwater areas of the Columbia River to complete their life cycles. Woodhouse's toad is listed as a monitor species by Washington State (WDW 1994).

Principal reptiles in the riparian zone include the gopher snake, painted turtle, side-blotched lizard, western garter snake, and western yellow-bellied racer (Fitzner and Gray 1991). The turtles are more often associated with ponds than the river but may be present in the sloughs where water velocities are low. None of the reptile species associated with the riparian zone are listed for protection by state or federal agencies.

4.1.1.2 Aquatic Community

Aquatic vegetation is comprised of three general groups: phytoplankton, periphyton, and macrophytes. Semi-aquatic or emergent vegetation, although generally rooted in standing water, is considered within the riparian vegetation described above. Diatoms dominate the Columbia River algae, comprising more than 90 percent of the biomass. The primary genera include Asterionella, Cyclotella, Fragillaria, Melosira, Stephanodiscus, and Synedra (Neitzel et al. 1982a; Brandt et al. 1993). The peak of phytoplankton abundance is in April and May, with a secondary peak in late summer and early autumn. Periphyton develops on suitable substrate where light is sufficient for photosynthesis. Diatoms also predominate among this group. Macrophytes are sparse outside of McNary Pool and slack water areas because they require relatively low flow and a sediment substrate in which to root. Common species include curled leaf pondweed, duckweed, and water milfoil. Where present, macrophytes provide food and shelter for juvenile fish and spawning substrate for some species of fish.

Zooplankton are generally sparse in the study area (Brandt et al. 1993; Neitzel et al. 1982b). Dominant genera are Bosmina, Cyclops, Diaptomus. Densities are lowest during winter and highest during summer.

Benthic invertebrates (invertebrate species associated with the substrate rather than the water column) include all major fresh water benthic taxonomic groups (Brandt et al. 1993). The invertebrate fauna is dominated by insect larvae, particularly black flies, caddisflies, and midge flies. Other benthic organisms include crayfish, limpets, snails, and sponges. Larval insect densities peak during late fall and winter with peak emergence occurring during spring and summer. Benthic invertebrates are important food items for nearly all juvenile and adult fish in the study area. The pebblesnail and shortface lanx (another mollusc) are candidates for listing as endangered, threatened, or sensitive by Washington State (WDW 1994).

A total of 44 species of fish is known to occur in the Hanford Reach (Cushing 1995; Gray and Dauble 1977). Chinook, coho, and sockeye salmon and steelhead trout use the Reach as a migration corridor to and from upstream spawning areas. The Hanford Reach supports the only major spawning habitat for the upriver bright race of fall chinook salmon within the main stem of the Columbia River (Dauble and Watson 1990). American shad (Cushing 1995) and steelhead trout (Gray and Dauble 1977)

may also spawn within the study area. Of the fish species known to occur within the study area, one—the bull (Dolly Varden) trout—is a candidate for listing as threatened or endangered under the Endangered Species Act (61 FR 7595-7613). Four others, the mountain sucker, Piute sculpin, reticulate sculpin, and sand roller, are listed as a monitor species by Washington State (WDW 1994).

4.1.2 Approach for Selecting Species

To identify the species that have a high potential for exposure to or effects from contaminants and that are culturally and ecologically important to the CRCIA Team, a two-tier screening approach was used (Table 4.1). Species groups considered in the screening process included fungi, algae, higher plants, and animals (fish, invertebrates, and terrestrial wildlife). Fungi were included after the master list of species was developed (Table C.1 in Appendix I-C). Non-fungal and non-algae micro-organisms in surface soil, surface water, and sediment were excluded from consideration in the master list of species. While microorganisms play a critical role in nutrient cycling and other energy processes in the Columbia River ecosystem, they are considered to be highly adaptable to environmental change. In addition, the microbial community structure may change in response to a toxicant without altering the overall functional status of that community because of the wide presence of microbiota and the redundancy of their metabolic processes. This means that any localized effects of a toxicant are likely compensated in a relatively short time and that the potential for long-term effects to the Columbia River community are low. The steps used throughout this two-tier screen were developed with the approval of the CRCIA Team.

We used several screens to reduce an overwhelming number of species to a manageable number to be evaluated. Table 4.1 provides an overview of the criteria for the screens and the selection process. One of the initial screens was developed by a panel of regional biologists. The other screens were developed after consulting and reaching agreement with the CRCIA Team. Each time we applied a screen the number of species was reduced. Several screens were used to arrive at the first tier, labeled the Tier I list of species. Several more screens were used to arrive at the second tier, labeled the Tier II list of species. The Tier II lists the species evaluated in the screening assessment of potential risk to the environment. After each screening, the CRCIA Team reviewed the resulting list and reinstated any species they felt the screen had inappropriately filtered out. Key terms to be familiar with when reading about the approach used to select species are as follows:

- **Biotic media are living organisms and their products.**
- **Abiotic media are inorganic (not living) materials.**
- **Biomagnifying contaminants are those that occur in higher concentrations at higher levels in the food chain.**
- **Non-biomagnifying contaminants are those that remain at the same concentration or decrease in concentration at higher levels in the food chain.**

4.1.2.1 Tier I Species Screen

A list of Tier I species was identified using the following protocol. Each step of the protocol is explained in the subsections.

This section describes the details of the various screens used to arrive at the species on the Tier I list.

Table 4.1. Selection Process and Criteria Used to Identify Species for the Screening Assessment of Ecological Risk to the Columbia River

Species Lists	Selection Process and Criteria	No. of Species
Master (listed in Table C.1, Appendix I-C)	List developed by PNNL staff based on species found in riverine and riparian habitats of the Columbia River between the vicinity of Priest Rapids Dam and the Columbia River estuary	496
Study Area (denoted as selected in Table C.1)	List developed by PNNL staff based on species found in riverine and riparian habitats of the study area: the Columbia River between the vicinity of Priest Rapids Dam and McNary Dam	368
Tier I (listed in Table C.2, Appendix I-C)	List developed by ◆ panel of regional biologists based on - commercial or recreational importance - legal protection status - key predator or prey species - high potential exposure to contaminants - available toxicological information - representativeness of a foraging guild ◆ PNNL selection of highest-scoring species from panel screening, resulting in 93 species ◆ CRCIA Team identification of key species based on cultural and ecological importance, resulting in 88 additional species	181
Interim Grouping (listed in Table C.3, Appendix I-C)	List developed by ◆ PNNL grouping some species based on similar life styles and trophic levels, resulting in 121 species/groups of species ◆ CRCIA Team adding 5 species based on cultural and ecological importance	126
Tentative Tier II (listed in Table 4.17)	List developed by ◆ PNNL based on highest rank in - exposure to biotic and abiotic media - exposure duration - acute radiation sensitivity ◆ CRCIA Team based on - cultural and ecological importance	66
Tier II (denoted as selected in Table 4.17)	List developed by PNNL with concurrence of CRCIA Team based on excluding ◆ species with a life style similar to that of another Tier II species ◆ species with low average summary scores (see Section 4.1.2.2.11) ◆ species that virtually never occur in the river or riparian zone	52

1. A master list was developed that included plant and animal species known to occur in the riparian and aquatic ecosystems of the Columbia River between the vicinity of Priest Rapids Dam and the Columbia River estuary.

2. The master list was reduced to 368 species that occur within the study area.

3. PNNL formed a panel of regional biologists who developed a set of six criteria for screening the study area species. Ninety-three species were identified based on the scoring results of these six criteria.

4. Based on cultural and ecological importance, an additional 87 species and fungi (added as a broad taxonomic group rather than individual species) were provided by the CRCIA Team to create a final list of 181 Tier I species.

4.1.2.1.1 Master List of Species. A master list of species was assembled that included terrestrial and aquatic plant and animal species known to occur in riverine and riparian habitats of the Columbia River between the vicinity of Priest Rapids Dam and the Columbia River estuary. The master list was developed by selecting species from databases and records maintained by the following federal and state resource management agencies associated with the Columbia River and its environs and by consulting the U.S. Army Corps of Engineers (1976):

- Bonneville Power Administration, Northwest Environmental Database
- Oregon Department of Environmental Quality, Columbia River Bi-State Program
- Oregon Department of Fish and Wildlife, Wildlife Diversity Plan
- Oregon Natural Heritage Program
- Pacific States Marine Fisheries Commission, Coordinated Information System
- U.S. Fish and Wildlife Service, Black Water Island Research Area
- U.S. Fish and Wildlife Service, McNary National Wildlife Refuge
- U.S. Fish and Wildlife Service, Ridgefield National Wildlife Refuge
- U.S. Fish and Wildlife Service, Umatilla National Wildlife Refuge
- U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge
- Washington Department of Fish and Wildlife, Priority Habitats Database
- Washington Department of Natural Resources Natural Heritage Program
- Washington State Energy Office, Pacific Northwest Rivers Study

Species distributions and habitat preferences were also obtained from these agencies. The majority of information was obtained from the U.S. Fish and Wildlife Service national wildlife refuges (Figure 4.3). Information on species distributions and habitat preferences was used to exclude species that primarily use upland areas. From the resulting master list, 368 species were identified as those that occur within the study area (Table C.1 in Appendix I-C). Because of the many aquatic and terrestrial ecological studies that have been conducted in the study area (see Section 4.1.1), the CRCIA Team concurred that no further field studies were necessary to identify study area species to be considered in the screening ecological risk assessment. (The results of the assessment are provided in Section 4.2.)

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Figure 4.3. Locations of U.S. Fish and Wildlife Service National Wildlife Refuges Consulted in Preparing the Master List of Species

4.1.2.1.2 Study Area List of Species. This and the following sections present the methodology used to select a limited number of species for the screening ecological risk assessment. (See Section 4.2 for the results of the assessment.) The rationale for the small number of species is that among the major taxonomic groups (amphibian, bird, fish, insect, mammal, plant, reptile, etc.) of the 368 study area species on the master list, many have similar life styles (either fully aquatic, semi-aquatic, or primarily riparian) and belong in the same trophic levels (carnivore, herbivore, omnivore, etc.). Where such similarities exist, these species likely contact contaminated media in much the same way. Thus, their potential exposure to contaminants is probably similar. Also, much of the data required to estimate contaminant exposure and the effects for many of the 368 species are lacking, which would greatly increase the uncertainty of the risk assessments for these species. Because of the redundancy in exposure and increased uncertainty in the risk assessments of the species for which data are lacking, the 368 study area species on the master list were reduced further in number.

PNNL formed a panel of regional biologists, who developed a set of criteria for screening the study area species (Table 4.2):

- commercial or recreational importance
- protection status under the Endangered Species Act or similar state legislation

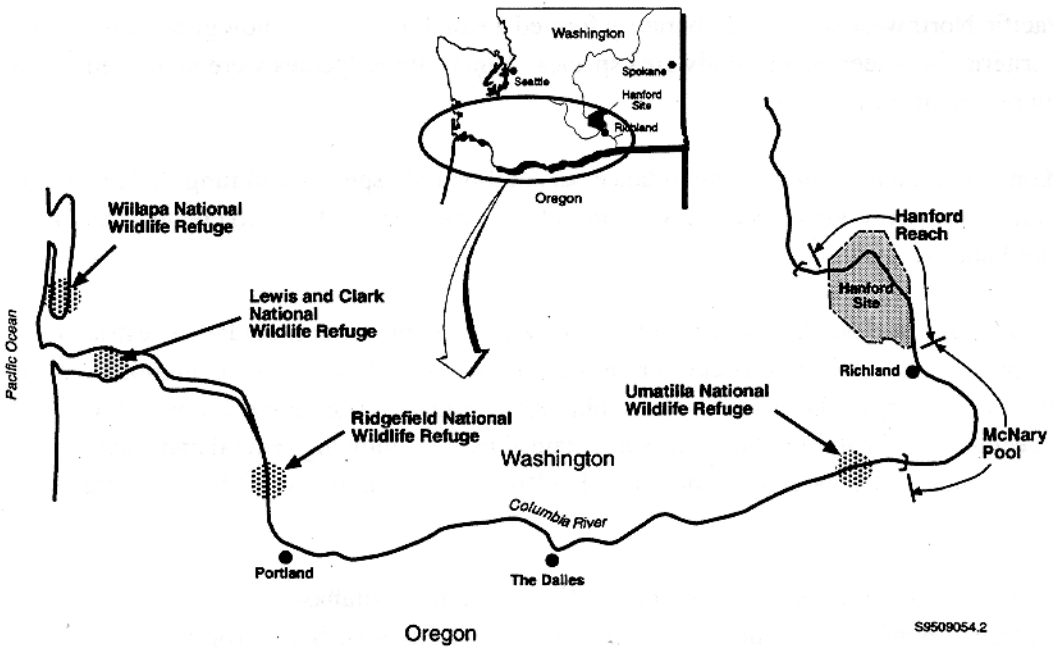

Figure 4.3. Locations of U.S. Fish and Wildlife Service National Wildlife Refuges Consulted in Preparation of the Master List of Species